THE RELATION OF BORON IN ILLINOIS SOILS TO THE GROWTH AND BORON CONTENT OF CROP PLANTS

BY

CHARLES HENRY STINSON

B. S., University of Illinois, 1933

M. S., University of Illinois, 1941

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRONOMY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1943

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I. Introduction

The problem of boron as related to plant growth has been the subject of many investigations especially since the work of Warington and Brandenburg within the last twenty years so clearly demonstrated the need for boron in plant life. It has been established that legume plants require larger amounts of boron for normal development than do plants of the grass family. Symptoms of boron deficiency have been described for many legumes. Boron deficiencies have been recognized in many soils of the United States mainly by recognizing the symptoms in the plants and then observing their disappearance and also frequent increases in yield following borax applications.

It has been suspected that boron deficiencies exist in the soils of various parts of Illinois because of increasing reports of symptoms of nutritional disorders occurring with certain legumes, especially alfalfa. The symptoms described in many of these reports resembled those known to be due to boron starvation. In southern Illinois, preliminary studies in applying borax to alfalfa which had shown these symptoms resulted in the development of apparently normal alfalfa as contrasted with that on the untreated plots. It was the purpose of this investigation to determine a.) the minimum boron requirement of alfalfa in terms of tissue concentration, b.) its relation to the soil supplying power as indicated by water-soluble content, and c.) the extent and severity of boron deficiency for this crop in Illinois, as a guide in recommending the use of borax fertilizer.

II. Experimental Procedure

Alfalfa has been shown to be especially sensitive to a shortage of available boron in the soil. Because of this and the fact that it is grown generally throughout Illinois, alfalfa was selected as the legume crop for the major portion of this study. Plant samples were taken in fields from widely distributed parts of Illinois during the summer of 1942; from each field a surface soil sample was also taken. When the samples were taken, all

apparent symptoms of physiological disorders were recorded. The total boron content of the plant samples was determined by an ignition-electrometric titration method (Wilcox). The available boron content of the soil was determined by hot water extraction and a colorimetric method (Berger and Truog).

III. Results and Conclusions

While symptoms of physiological disorders due to a deficiency of boron vary somewhat in alfalfa, the most certain symptom is a pronounced shortening of the upper internodes of a given shoot, accompanied by the development of lateral shoots from the uppermost buds. The laterals frequently extend beyond the tip of the central shoot, producing a rosette effect. In cases of extreme deficiency, abnormal colorations such as yellowing, reddening, or bronzing of the leaves or a combination of any of these may accompany the rosetting. Such discolorations are always confined to the leaves on the terminal growth of the main stem or laterals, whereas other discolorations occur at various heights on the shoot. Premature leaf fall, failure to flower, failure to set seed in flowers that appear, and a shortening of the life of the alfalfa plant are also described as symptoms of boron deficiency in alfalfa.

Symptoms of boron deficiency were most pronounced in alfalfa that contained the least amount of boron. In only a few cases were alfalfa plants containing less than twenty p.p.m. of boron free of symptoms and in no case were there observable symptoms of deficiency in alfalfa containing more than twenty p.p.m. of boron. Moisture deficiency during the growing season tends to accentuate the development of symptoms, possibly by interfering with boron uptake by the plants. Unusually heavy rains throughout most of the growing season of 1942 in Illinois were probably responsible for the general scarcity of symptoms in that year.

In alfalfa which shows extreme deficiency symptoms, the upper portion of the plant is much lower in boron concentration than other parts of the plant. In normal alfalfa, on the other hand, the boron in the upper portion is greater than in the lower part of the plant. This relationship suggests that boron becomes fixed or permanently combined in growing tissue and cannot be

later translocated from the older to the actively developing parts of the plant. This helps to explain the necessity of a continuously available supply of boron in the substrate during the whole of the life cycle.

The total boron content of the plant varies directly with the water-soluble boron content of the soil, the correlation factor (r) for fifty-two cases studied being .848 and the regression factor, 2.5. The standard error of r (Er) is .076 and the P value is 0.01 (i.e., on the average, in only one case in a hundred is there no relationship between the available or water-soluble boron in the soil and the total boron content of the plant). The boron content of the plant is increased by applications of borax to the soil and boron deficiency symptoms are prevented. When applied to boron deficient soils, there is also visible evidence of increased growth, although no quantitative data were obtained in this study. Appreciable seed set in alfalfa was induced with borax on boron deficient soils at Oblong in 1941 but no significant seed set in either treated or untreated alfalfa was observed at any place in Illinois in 1942. It is therefore apparent that boron deficiency in Illinois is only one of probably several conditions, including weather, which control seed set or its failure.

Boron deficiencies for alfalfa appear to exist in the more highly weathered soils of Illinois which contain less than 0.50 p.p.m. of water-soluble boron. Legume plants growing on such soils may be expected to contain less than 20 p.p.m. of total boron, and, as far as alfalfa is concerned, deficiency symptoms are very likely to appear. Soils having more than 0.50 p.p.m. of water-soluble boron probably will assure a concentration sufficient for most plants and alfalfa may be expected to develop normally and contain from 20 to 30 or more p.p.m. of total boron. The critical value for the coarser or sandier soils appears to be about 0.30 p.p.m.

The results presented, considered with the available knowledge of the productivity levels of the different groups of Illinois soils, indicate a direct relation between productivity levels of soils and the water-soluble boron supply in them. Inasmuch as most Illinois soils are derived from similar parent materials, it is suggested that the factors which have resulted in deficiencies of other plant nutrient elements in the more mature soils have

been responsible likewise for a boron deficiency. In general, boron deficiencies are widespread in the soils of the southern third of Illinois and in some years they may extend into other parts of the state, especially in dry seasons.

VITA

The author was born August 8, 1911, near Eldorado, Illinois. He graduated from the Eldorado Township High School in 1928 and entered the University of Illinois in the fall of that year. In the spring of 1929, the writer was employed as the dairy herd-improvement test supervisor in Coles County, Illinois, and resigned in September, 1930, to resume his studies at the University. He graduated from the University in 1933, receiving the degree of Bachelor of Science in Agriculture.

From then until September, 1939, the writer was employed by the U. S. D. A. Soil Conservation Service as Agronomist and Junior Conservationist in southern Illinois. In September, 1939, he was appointed Assistant in Crop Production at the University of Illinois, teaching half-time in the basic crop production course for undergraduate students. He continued in this role until September, 1942, having received in the meantime the degree of Master of Science in Agronomy in February, 1941. Since September, 1942, he has been a Special Research Assistant in Soil Fertility, Agronomy Department, University of Illinois.

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